Economic development, ecosystem modifications, and emerging infectious diseases risk evaluation project (ECOMORE I)

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Summary

Unprecedented economic growth in South-East Asia (SEA) has encouraged the expansion of rubber plantations. There is expected to be an increased dengue, malaria and chikungunya risk for rubber workers, with migrant rubber workers identified as a vulnerable population group. Data on the relationship between mosquito vectors and the presence of the diseases in these rubber plantations is limited. We carried out several entomological and social studies in northern Lao PDR to assess the dynamics of vector-borne diseases in rubber plantations compared to rural villages and to identify how to mitigate these risks.

We demonstrated that the Human-baited Double Net trap (HDN) is an efficient and ethically sound method for surveying outdoor-biting adult mosquitoes in rural Lao PDR. Using this method, we assessed the mosquito dynamics in rubber plantations and surrounding rural villages and secondary forests. A total of 24,927 female mosquitoes were collected during nine months of adult mosquito surveys, including 61 species not documented in the country before. High species diversity was found in all habitats investigated, including vectors of dengue, Japanese encephalitis (JE), lymphatic filariasis and malaria. Molecular analyses were conducted to confirm Anopheles species and, presence of arboviruses and flaviviruses in the mosquitoes.

Risk of dengue vector exposure, compared to staying in the village, was 36 times higher for villagers that visited the secondary forests. Working in rubber plantations increased risk of dengue vector exposure 16 times compared to staying in the village, with risk exacerbated when people also lived in these plantations. Furthermore, when visiting the secondary forests during the day risk of exposure to JE vectors was 1.4 times higher and exposure to malaria vectors 1.3 times higher compared to staying in the village. However, working and
living in the plantations decreased risk of malaria exposure by 1.6 times compared to staying in the village. The data collected on *Aedes albopictus* in this project have been combined with the insecticide resistance data from the ARBOVEC project into a comprehensive paper on the bionomics and resistance status of *Ae. albopictus* in northern Lao PDR.

To identify the times and places where disease vectors and people overlap in behavior, we conducted several social surveys and focus group discussions in the study area. Although risk of dengue exposure was highest in the secondary forests, human activity was significantly higher in the rubber plantations. Therefore, the rubber plantations were identified as the main habitats for dengue transmission. One of the most important methods to protect the local population and vulnerable migrant rubber workers in the plantations from vector-borne diseases, is the implementation of larval control. We identified the main breeding sites for vector mosquitoes during six months of surveys. Control of mosquitoes should focus on preventing water accumulation in latex collection cups, tree trunks, cut bamboo, puddles and garbage. Additionally, the use of personal protection methods is recommended, when visiting the plantations and secondary forests.

In this study, we have involved the important stakeholders from the beginning of the project. By organizing regular stakeholder meetings throughout the three year project, we have ensured that the results obtained from the study are of interest for the different stakeholders. The stakeholder meetings were a platform for us to present my preliminary data and receive ideas and comments from the participants. This has resulted in the inclusion of our work in documents from both the Ministry of Health and Ministry of Agriculture and Forestry.

In SEA the rubber plantations have been described as mosquito box amplification habitats by Sumodan *et al.*, with increased
risk of dengue, malaria and chikungunya diseases [1]. Although other studies in SEA have shown the increased Transfusion transmitted infections (TTI) are a significant burden on national health care systems worldwide. While hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) are the leading causes of TTI, numerous other pathogens capable of being transmitted with blood products escape standard detection procedures. Since transfusion transmitted viruses missed by routine blood screening may cause a new infection or exacerbate others an existing disease (e.g. parvovirus B19 induced aplastic crisis in patients with hemoglobinopathies), patients with thalassemia and sickle cell anaemia, who require regular blood transfusions, are at a higher risk of contracting TTI. At the same time those patients are particularly vulnerable to co-morbidities associated with newly acquired TTI. The high prevalence of thalassemia in Lao PDR and the lack of epidemiological data about the prevalence of TTI in those patients warrant a detailed investigation of the TTI in multiple transfused children in Lao PDR.

We did however identify increased risk of dengue when working and living in the rubber plantations, which corresponds with results from other studies in the region [7-9]. Currently, deployment of long lasting insecticidal nets and indoor residual spraying in villages accounts for the majority of vector control methods used in Lao PDR, while people were most likely to be infected in neighboring rubber plantations and forests. The results from this study have been translated into clear recommendations which have been communicated to the public health workers, governments and those working in the rubber industries of Lao PDR in cooperation with the Ministry of Health and Ministry of Agriculture and Forestry. This work represents a comprehensive approach to assess disease risk and how to control these, based on studies of adult and immature mosquito stages as well as the behavior of people in different habitats in northern Lao PDR. It is of great importance to
conduct further entomological surveys in other parts of SEA to understand the local dynamics of vector-borne diseases, especially in malaria endemic areas. With growing evidence of increased vector-borne disease risk in SEA rubber plantations, it is of interest to identify the vector-borne disease dynamics in rubber plantation areas of Africa and South America.

Recommendations for the Lao health officials and rubber industry

This study was conducted to understand the dynamics of vector mosquitoes in northern Lao PDR which could be translated into recommendations for the local Lao health officials and the rubber industry stakeholders. The most important recommendation from this study is the necessity to include rubber plantations in vector control programs, which are currently mainly focused on the distribution of long lasting insecticide-treated nets (LLINs) and indoor residual spraying (IRS) in the villages. In the rubber plantations the following larval control can be implemented. If latex tapping is not conducted for more than one week, all latex collection cups should be turned upside down to avoid Aedes and to a lesser degree Culex breeding. This is also important when latex is not collected for more than one week, as mosquitoes can breed in water that collects over the latex layer. After latex tapping is completed for the season, all latex collection cups should be collected in roofed sheds to diminish breeding sites during the non-tapping season. To further decrease Aedes and Culex mosquitoes, the water containers and other waterbodies surrounding the rubber and village houses should be covered with a lid or netting, or treated with an insecticide or the microbial larvicide, Bacillus thuringiensis israelensis (Bti). The rotation of the used larvicides is of paramount importance to decrease the selection for resistant larvae. As there is already decreased susceptibility of mosquito larvae to temephos in the area, this insecticide is only recommended in
rotation. Although there have been suggestions that the selection of resistance against larvicides can benefit the control efforts, if the resistance leads to a shortened lifespan or reduced biting behavior [10]. Moreover, all garbage in plantations and villages should be properly disposed of in closed containers, including unused tires. When using bamboo for construction, the open end of bamboo poles should be filled with gravel, cut at the joint or in the length to further decrease Aedes mosquitoes breeding. Tree trunks in the villages and rubber plantations should be removed as they are good breeding sites for Aedes and Anopheles mosquitoes. Mud roads in the plantation and villages contain road puddles where Anopheles mosquitoes breed. These puddles should therefore be levelled by filling the cavities with gravel. This needs to be done regularly during the rainy season when road use is intensive. Tarmac roads would reduce pooling more permanently, providing there was good drainage on either side of the road. To achieve sustainable larval control, the recommendations should be communicated and implemented during regular community-based mosquito source reduction activities.

Rubber workers should be encouraged to live in villages instead of inside the plantations, as this decreases exposure to dengue (which is a bigger risk in the study area than JE or malaria is). Additionally, our study has shown the necessity of outdoor protection against vector mosquitoes to complement the larval control. The local population should be encouraged to use methods that are known to decrease mosquito bites, including wearing thick long-sleeved clothing and applying topical repellents when visiting the natural and man-made forests [11,12]. Moreover, it should be safeguarded that all rubber worker families and villagers have access to LLINs, as vectors are seeking blood meals in the evening and at night when people (including the families of the rubber workers) are asleep. Personal protection methods such as insecticide-treated clothing and insecticide emitters should be compared outdoors in the field for their efficacy (This has been...
conducted as part of the Yersin project. Please consult this project summary for results). It is, furthermore, essential to understand the community level protection of these methods. When this information is available, the mandatory use of personal protection methods by plantation workers can be discussed, as has been done in Bolivia [13].

Additional recommendations that are not directly related to the study results, but which are important for mitigating vector-borne disease risk is the education of the population and the swift treatment of the diseases. Of key importance is to improve the education of the local population and rubber workers on the vector-borne diseases and how to decrease their risk of exposure. Additionally, villagers should be taught why it is important to go to health centers when febrile, especially if they have just travelled from outside their district. Apart from the education of the population, the local health services should be prepared for outbreaks of dengue and malaria. Rapid diagnostic tests should be available in the local health hospitals to identify dengue and malaria. Similarly, malaria medicine should be available in the hospitals, even in non-endemic areas, so that malaria cases can be swiftly dealt with. The health workers should be provided sufficient training to conduct the tests, analyze the results and recommend treatment. Appropriate preparation for outbreaks also include regular surveys of disease incidence, which should be followed closely by the provincial health offices for early warning of outbreaks. These early warnings should result in the implementation of a clear action plan which focusses on the treatment of patients, communication to the affected areas and mosquito control.

Publications from the ECOMORE project

2017 Tangena J-AA, Marcombe S, Thammavong P, Chonephetsarath S, Somphong B, Sayteng K, Grandadam M, Sutherland IW, Lindsay SW, Brey PT: Bionomics and insecticide resistance of the
arboviral vector *Aedes albopictus* in northern Lao PDR.<In review>


**References**


Centers for Disease Control and Prevention (2013) Avoid bug
